

Your Name: _____

PHY203
Exam #3
Chapters 9-11,15
~~2007???~~

Mon, Dec. 8, 2025

Solutions



1. A disk (A) of mass 9.50 kg is traveling on a frictionless surface in the +x direction with a speed of 15.5 m/s. It explodes into two pieces, B and C. Piece B of mass 5.00 kg travels off in the +y-direction with a speed of 17.0 m/s.

a. List the known quantities before the explosion:

Parameter	Known Value
M_A	9.50 kg
V_A	15.5 m/s \hat{i}
M_B	5.00 kg
V_B	17.0 m/s \hat{j}

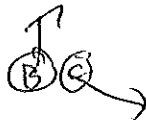
b. Find the linear momentum of disk A before the explosion and write it in vector notation. 10

$$\vec{p}_A = (9.50)(15.5) = 147 \text{ kg m/s } \hat{i}$$

c. Find the linear momentum of piece B after the explosion and write it in vector notation. 10

$$\vec{p}_B = (5.00)(17.0) = 85.0 \text{ kg m/s } \hat{j}$$

d. Draw a sketch of the situation just after the explosion. 5

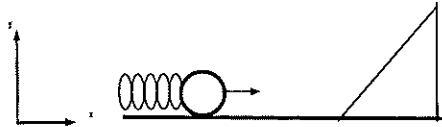


e. Find the velocity of piece C after the explosion and write it in vector notation. 10

$$x: \quad 147 = 0 + 4.50 v_x, \quad v_x = 32.7 \text{ m/s}$$

$$y: \quad 0 = 85.0 + 4.50 v_y, \quad v_y = -18.9 \text{ m/s}$$

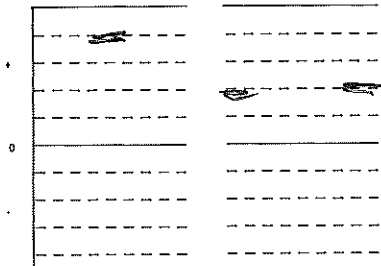
$$\vec{v}_C = (32.7 \hat{i} - 18.9 \hat{j}) \text{ m/s}$$



2. A hollow cylinder is held against a spring with a spring constant of 1.50 kN/m. Initially the cylinder is held such that the spring is compressed by 0.350 m. The cylinder is released and rolls w.o. slipping on a horizontal surface. The mass of the cylinder is 5.00 kg; the radius is 0.750 m.

a. Create energy bar charts. Take the final position as the cylinder rolling on the horizontal surface before reaching the ramp. 5

K_t U_{grav} U_{spring} K_{rot} K_t U_{grav} U_{spring} K_{rot}



b. Find the linear speed of the cylinder as it rolls on the horizontal surface. 20

$$\begin{aligned}
 \frac{1}{2} k x^2 &= K_t + K_{\text{rot}} \\
 &= \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 \\
 &= \frac{1}{2} m v^2 + \frac{1}{2} (m r^2) \frac{v^2}{r^2} \\
 k x^2 &= 2 m v^2 \\
 v^2 &= \frac{(1.5 \times 10^3)(.35)^2}{2 \cdot 5} = 18.4 \\
 v &= 4.29 \text{ m/s}
 \end{aligned}$$

c. Find the maximum height the cylinder reaches when it rolls up the ramp. 10

$$\begin{aligned}
 \frac{1}{2} k x^2 &= m g h \\
 h &= \frac{(1.5 \times 10^3)(.35)^2}{2 \cdot 5 \cdot 9} = 1.87 \text{ m}
 \end{aligned}$$

3. A block of mass, m , on a frictionless table is attached to a spring with spring constant, k , stretched by a distance D and released at $t=0$.

a. Write an equation of motion for the block (x as a function of t) using the variables as given: 5

$$x = D \cos \omega t = D \cos \sqrt{\frac{k}{m}} t$$

b. Assume the maximum velocity is 8.50 m/s, the amplitude is 0.500 m, and the mass is 2.50 kg. Find the angular frequency and the spring constant. 15

$$v_{max} = \omega D = 8.50$$

$$\omega = \frac{8.50}{0.5} = 17.0 \text{ rad/s}$$

$$k = m\omega^2 = (2.50)(17)^2 = 722 \frac{\text{N}}{\text{m}}$$

c. Find the acceleration of the block at a time of 0.100 s. 10

$$a = -\omega^2 D \cos \omega t$$

$$= -(17)^2 (0.500) \cos(17 \cdot 0.1)$$

$$= -144.5 \cos(1.7)$$

$$= 18.6 \text{ m/s}^2$$

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1. A disk (A) of mass 8.50 kg is traveling on a frictionless surface in the +x direction with a speed of 16.5 m/s. It explodes into two pieces, B and C. Piece B of mass 4.00 kg travels off in the +y-direction with a speed of 14.0 m/s.

a. List the known quantities before the explosion:

Parameter	Known Value
M_A	8.50 kg
V_A	16.5 \hat{i} m/s
M_B	
V_B	

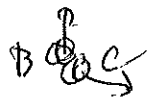
b. Find the linear momentum of disk A before the explosion and write it in vector notation. 10

$$\vec{p}_A = (8.50)(16.5)\hat{i} = 140\hat{i} \text{ kg}\cdot\text{m/s}$$

c. Find the linear momentum of piece B after the explosion and write it in vector notation. 10

$$\vec{p}_B = (4.00)(14.0)\hat{j} = 56.0\hat{j} \text{ kg}\cdot\text{m/s}$$

d. Draw a sketch of the situation just after the explosion. 5



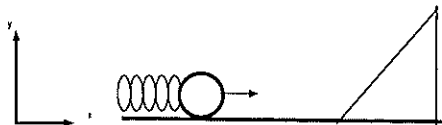
$$m_C = 8.5 - 4 = 4.50 \text{ kg}$$

e. Find the velocity of piece C after the explosion and write it in vector notation. 10

$$x: 140 = 4.50 v_{xc}, v_{xc} = 31.1 \text{ m/s}$$

$$y: 0 = 56.0 + 4.50 v_{yc}, v_{yc} = -12.4 \text{ m/s}$$

$$\vec{v}_C = (31.1\hat{i} - 12.4\hat{j}) \text{ m/s}$$

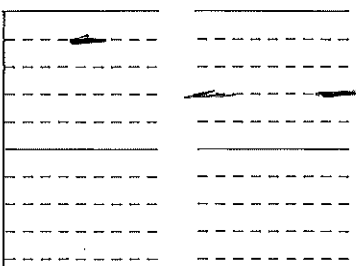


2. A hollow cylinder is held against a spring with a spring constant of 2.50 kN/m. Initially the cylinder is held such that the spring is compressed by 0.300 m. The cylinder is released and rolls w.o. slipping on a horizontal surface. The mass of the cylinder is 6.00 kg; the radius is 0.850 m.

a. Create energy bar charts. Take the final position as the cylinder rolling on the horizontal surface before reaching the ramp. 5

K_t U_{grav} U_{spring} K_{rot}

K_t U_{grav} U_{spring} K_{rot}



b. Find the linear speed of the cylinder as it rolls on the horizontal surface. 20

$$\frac{1}{2} kx^2 = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$$

$$kx^2 = m v^2 + m R^2 \frac{v^2}{R^2} = 2 m v^2$$

$$v^2 = \frac{kx^2}{2m} = \frac{(2,50 \times 10^3)(0.3)^2}{2 \cdot 6,00}$$

$$v = 4,33 \text{ m/s}$$

c. Find the maximum height the cylinder reaches when it rolls up the ramp. 10

$$E_i = \frac{1}{2} kx^2 = mgh$$

$$h = \frac{(2,50 \times 10^3)(0.3)^2}{2g(6,00)} = 1,81 \text{ m}$$

3. A block of mass, m , on a frictionless table is attached to a spring with spring constant, k , stretched by a distance D and released at $t=0$.

a. Write an equation of motion for the block (x as a function of t) using the variables as given: 5

$$x = D \cos\left(\sqrt{\frac{k}{m}} t\right)$$

b. Assume the maximum velocity is 9.50 m/s, the amplitude is 0.600 m, and the mass is 3.00 kg. Find the angular frequency and the spring constant. 15

$$v = -\omega A \sin \omega t, \quad v_{\max} = \omega A$$

$$9.50 = \omega (0.6), \quad \omega = \frac{9.50}{0.6} = 15.8 \text{ rad/s}$$

$$k = m \omega^2 = (3.00) (15.8)^2$$

$$= 752 \text{ N/m}$$

c. Find the acceleration of the block at a time of 0.150 s. 10

$$a = -\omega^2 A \cos \omega t$$

$$= -(15.8)^2 (0.6) \cos (15.8)(0.150)$$

$$= 107 \text{ m/s}^2$$